H.265/HVC における高性能符号化アルゴリズムに関する研究

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High Efficient Intra Coding Algorithm for H.265/HVC

by

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Abstract

This work proposes a novel INTRA coding algorithm which can achieve high coding efficiency using temporal-spatial prediction for H.264/AVC. The proposed prediction algorithm can compensate the weak point of individual usage of spatial or temporal prediction. Firstly, a new prediction block is selected in the temporal previous frame. Next, the selected block in the previous frame is used as the reference data to perform spatial prediction with the same reference direction as traditional INTRA modes. The coding process can also be reconstructed in decoder side without additional bit transfer. The simulation results show that the proposed new INTRA modes can achieve about 1dB improvement than the original H.264/AVC.

Key words: INTRA, H.265/HVC, HEVC

1. Introduction

H.264/AVC is an outstanding video coding standard which is recommended in 2003 [1]. It still uses a traditional MC-DCT based hybrid coding structure. Two types of prediction modes are introduced in H.264/AVC which are the INTER and INTRA prediction to reduce the temporal and spatial redundant components. For INTER type modes, 7 kinds of block size with 4x4 to 16x16 pixels can be used to make efficient motion compensation. In addition to it, multiple frames and half/quarter precision prediction are also available to further improve the coding efficiency. However, the motion compensation tools help to only reduce the temporal redundancy in the case of continuous motions. In the case when there are significant motions or too much high frequency components in the sequences, these INTER modes cannot provide sufficient coding efficiency. Therefore, INTRA modes are used to reduce the spatial redundancy. In H.264/AVC, 4x4 or 16x16 pixels modes are used to predict from the adjacent blocks. All modes of both the two types are pre-encoding by a rate-distortion optimization (RDO) process and the most efficient mode is selected as the final coding mode. This mechanism works well in almost cases because INTRA modes can work well as a supplemental tool when INTER modes cannot achieve good performance. However, in some cases neither the temporal nor the spatial redundancy can be reduced, H.264/AVC has to select a relatively efficient mode and it induces significant bitrate increasing. A traditional difficulty which is familiar to many researchers is the sequence of "Football". In "Football", temporally redundancy is

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difficult to be reduced due to its fast motions as well as the spatial redundancy is difficult to be estimated for its high complexity texture. As a result, unstable high bitrate consequent high cost of hardware and software implementation.

Almost of previous works dedicate to the improvement of complexity reduction of INTRA coding [2]. These works try to reduce the candidate modes from several different viewpoints. However, any proposal cannot avoid the decrease of coding efficiency. Some previous works mentioned the spatial-temporal prediction concept [3]. A low complexity coding structure is proposed using joint predictive coding method [4]. Kaup's group proposed several efficient algorithms to improve the inter coding efficiency by refining the reference blocks [5][6]. These proposals combine the spatial-temporal prediction to improve the coding efficiency from the viewpoint of the refinement of INTER coding modes. However, no previous work really combines the temporal correlation to spatial estimation.

2. INTRA prediction

In H.264/AVC, 9 different INTRA prediction modes for 4x4 blocks and 4 different INTRA prediction modes for 16x16 blocks are available, including one DC mode and 8 directional modes as illustrated in Fig.1.

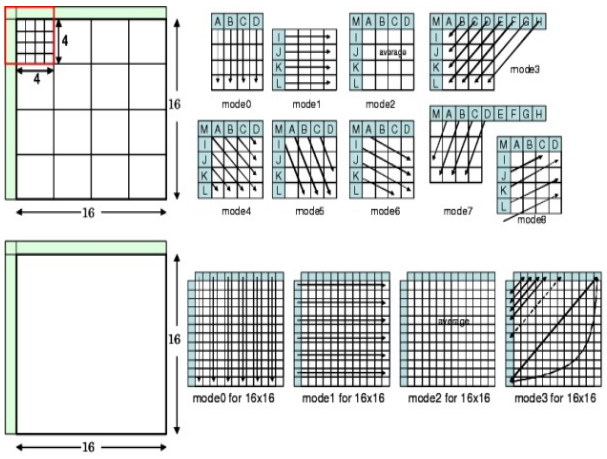


Fig.1 Intra prediction modes in H.264/AVC

Another simulation result which is shown in Table 1 indicates the correlation of the selected INTRA modes between continuous frames.

The INTRA MB indicates the number of macroblocks (MB) encoded by INTRA type modes and the INTRA-INTRA indicates the number of MBs with the same INTRA type encoded MB in the correlation MB or surrounding MBs.

Table 1: INTRA block tendency

Sequences	INTRA MB	INTRA-INTRA MB	Rate[%]
Bus	508	359	70.67
Coastguard	360	272	75.56
Football	9744	9506	97.56
Foreman	663	406	61.24
Mobile	114	30	26.34
Tempete	811	706	87.05

As Table 1 shows, it has very high probability to get continuous INTRA mode in the continuous frames. Moreover, the INTRA encoded correlated MB can be used to predict the reference pixels for the INTRA mode encoding in the current frame.

3. Proposed Algorithm

A novel temporal prediction is introduced in addition to the traditional INTRA modes. The proposed algorithm can be described by Fig.2.

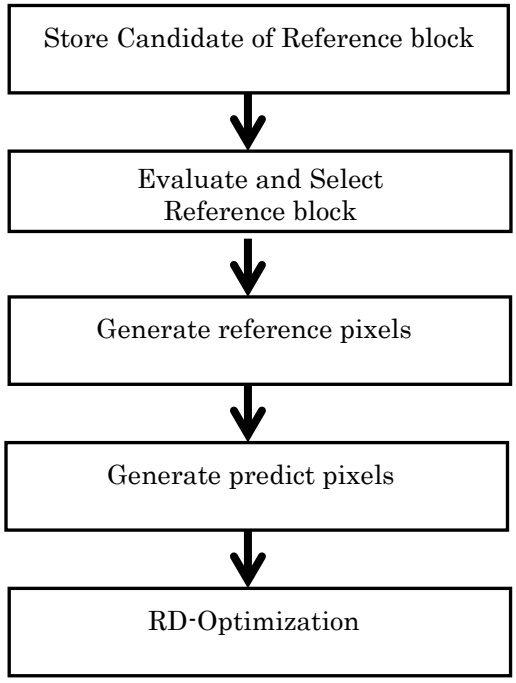


Fig.2 Flowchart of the proposed algorithm

As Fig.2 shows, the proposed new modes are performed together with the traditional INTRA modes. The details for reference pixels generation and predictor generation will be introduced in the following subsections.

1. Candidate block selection

In this work, we try to find high performance reference pixels in the previous frame. An efficient method is performing block matching algorithm to find the best reference block which is a time consuming solution. On the basis of our simulation results, we notice that if the collocated MB in the previous frame is encoded by INTRA type, the selected coding mode for current MB has deep correlation with it. In this work, in the RDO process of the current MB only when the correlated MB is encoded by 4x4 INTRA mode, we select the majority modes in the correlated MB as candidate blocks which are shown in Fig.3.

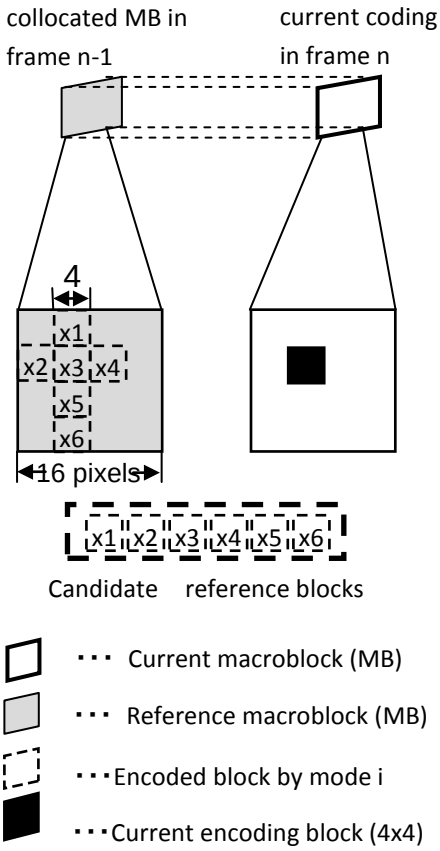


Fig.3 The proposed algorithm

As shown in Fig.3, the block x1~x6 are encoded with the same mode and becomes the majority mode in the 16 4x4 blocks of the correlated MB. This method for candidate block selection can reduce the computation complexity and make it possible to be reconstructed in the decoder side.

2. Similar block selection

All the candidate blocks with the majority mode are compared with current block to select the most similar block. The residual between the current block and x1~ x6 are calculated respectively with equation

$$\mathrm{Re}\,sidual = \sum_{i=0}^{15} | P(i)_{current} - P(i)_{candidate} |$$

where $P(i)_{current}$, and $P(i)_{candidate}$ are the collocated pixel in the current and candidate blocks. The block with the smallest residual in x1~x6 will be selected as the most similar block. The selected similar block is used to generate the reference pixels.

3. Reference and predictor pixels generation

Using the pixels of the selected block, the reference pixels are generated with an inverse process of the traditional INTRA reference pixel generation. The reference pixels and the generation process are shown in Fig.4.

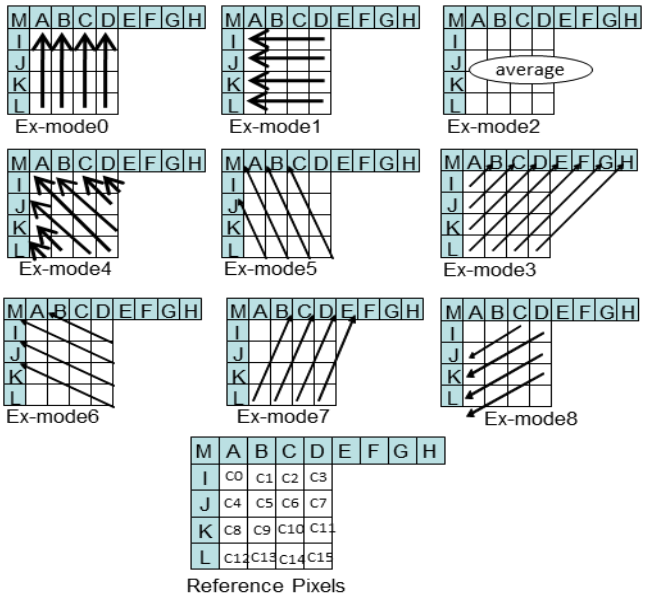


Fig.4 The proposed reference pixels generation

As Fig.4 shows, totally 9 new modes are introduced addition to the traditional 9 INTRA modes. The pixels of the selected similar block is indicated by C_0 ~C_{15}. These pixels are used to generate reference pixels A~M. The generation of reference pixels A ~M is an inverse process of traditional predictor generation.

Finally, the proposed 9 novel modes perform the same prediction as the traditional modes on the same direction but with new generated predictors.

4. Simulation Results

The proposed algorithm is implemented in the reference software JM [7]. Test sequences of "bus", "coastguard", "football", "foreman", "mobile", and "tempete" are used. The simulation conditions are concluded in Table 1 and the simulation results are shown in Table 2.

In these simulations, only the first frame is encoded as I frame, other frames are coded as P frame.

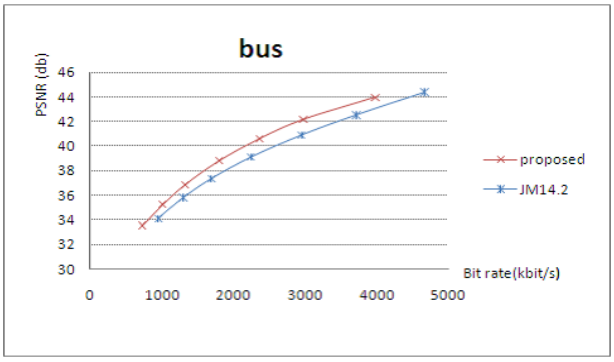
Table 2: Simulation conditions

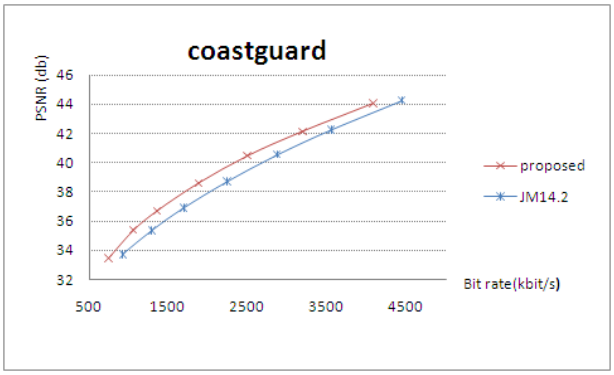
Codec	JM 14.2
Resolution	CIF
Frame rate	30Hz
Frame numbers	65
Profile	High Profile
CABAC	ON
QP	24, 26, 28, 30
GOP size	16

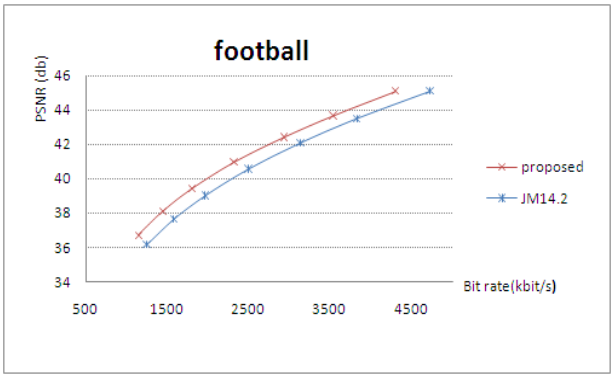
Table 3 : Simulation results

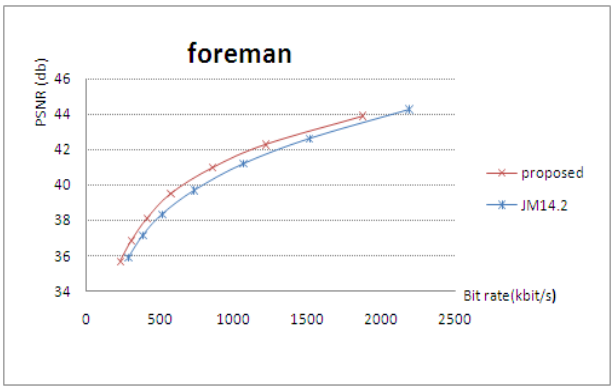
Sequences	PSNR[dB]	Bitrate[%]
Bus	0.53	-8.75
Football	0.48	-7.61
Foreman	0.30	-7.34
Tempete	0.63	-11.3
Akiyo	0.12	-2.07
Mobile	0.31	-5.26
Coastguard	0.45	-8.62
Average	0.40	-7.28

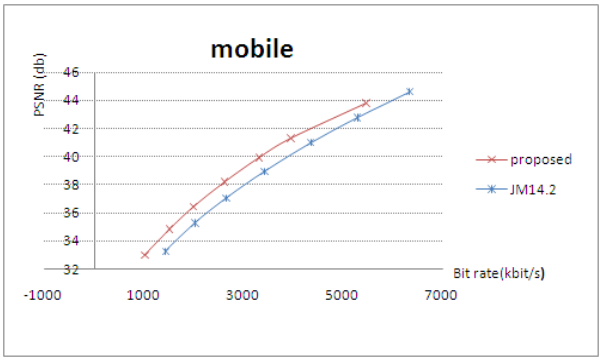
The coding performance is evaluated by R-D curves. Fig.~5 show the simulation results. From these figures, it is clear that the proposed algorithm achieves over 1dB coding gain on average compared to traditional JM.

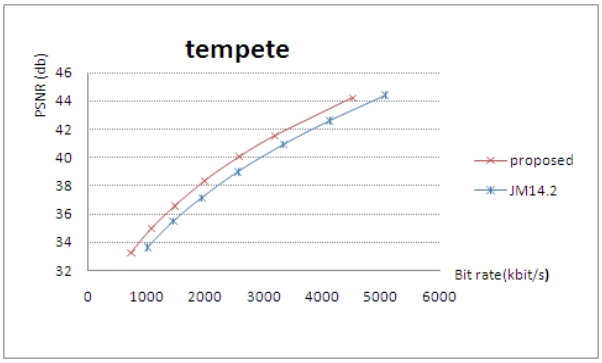












5. Conclusion

This work proposed a novel INTRA coding algorithm which can realize high coding efficiency using temporal-spatial prediction for H.264/AVC. The proposed prediction algorithm can compensate the weak point of individual usage of spatial or temporal prediction. The simulation results show that the proposed new INTRA modes can achieve about 1dB improvement than the original H.264/AVC.

References

[1] ISO/IEC 14496-10:2003. Information technology coding of audio-visual objects-Part 10: advanced video coding. Dec. 2003.

[2] T. D. Chuang, Y. H. Chen, C. H. Tsai, Y. J. Chen, and L. G. Chen, "Algorithm and architecture design for intra prediction in H.264/AVC high profile", in Proc. of Picture Coding Symposium, 2007.

[3]L. Zhang, S. W. Ma, W. Gao, "Position dependent linear intra prediction for image coding", in Proc. of Int. Conf. on Image Processing(ICIP), pp.2877-2880, 2010.

[4] W. F. Jiang, L. J. Latecki, W. Liu, H. Liang, and K. Gorman, "A video coding scheme based on joint spatiotemporal and adaptive prediction," in IEEE Trans. on Image Processing, vol.18, pp.1025-1036, 2009.

[5]J. Seiler, and A. Kaup, "Spatio-temporal prediction in video coding by spatially refined motion compensation," in Proc. of Int. Conf. on Image Processing(ICIP), pp.2788-2791, Oct. 2008.

[6]J. Seiler, T. Richter, and A. Kaup, "Spatio -temporal prediction in video coding by non-local means refined motion compensation," in Proc. of Int. Conf. on Picture Coding Symposium (PCS), pp.318-321, Dec. 2010.

[7] JM14.2 (http://iphome.hhi.de/suehring/tml/)